THE CLINICAL SIGNIFICANCE OF TOTAL AND DIFFERENTIAL LEUKOCYTE COUNTS, WITH SPECIAL REFERENCE TO ACUTE INFECTIONS.*

BY WALTER CLINTON JONES, M.D.

DIRECTOR, PATHOLOGICAL DEPARTMENT, ST. VINCENT'S HOSPITAL, BIRMINGHAM, ALABAMA,

AND

CLARA ENERIE BROWN,

BIRMINGHAM, ALABAMA.

(From the Pathological Department of South Highlands Infirmary, Birmingham, Alabama.)

AFTER a thorough review of the extensive literature on this subject, we have formulated the following brief conclusions as being especially pertinent to the theme in hand.

I. **Total White Count and Percentage of Polymorphonuclears.** (1) The majority of writers agree that in most acute infections the total number of leukocytes in the blood is a measure of the patient's resistance and that the percentage of polymorphonuclears is an index of the severity of the inflammation. To Sondern[1] very largely belongs the credit of establishing these two all important principles. (2) Some authorities rely mostly on the total count, while others depend more on the percentage of polymorphs; but reliance on either to the exclusion of the other is frequently misleading. Of the two, however, the differential count probably has the greater value; but neither should be omitted in any critical case.

II. **Lymphocytes.** (1) Reduction in the number of lymphocytes below normal, especially below the normal number per cubic millimeter, is an unfavorable development; and an increase in their number, if not too excessive, is a favorable prognostic point. This conclusion seems to have been reached especially in tuberculosis, but it most likely applies also to various other diseases both acute and chronic. (2) The significance of an increase or a decrease in the number of small lymphocytes alone or of the large ones exclusively, does not seem to be understood.

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[1] The Present Attitude of Blood Examination for Diagnostic Purposes, Boston Med. and Surg. Jour., 1905, **153**, 690-692. Idem, The Present Status of Blood Examination in Surgical Diagnosis, Med. Rec., 1905, **67**, 452-455. Idem, Value of the Blood Count in Sepsis, New York Med. Jour., 1906, **83**, 1245-1246. Idem, The Value of the Differential Leukocyte Count in Gynecology and Abdominal Surgery, Med. Rec., 1906, **70**, 989-990. Idem, The Value of the Differential Leukocyte Count in Diagnosis, AM. JOUR. MED. SC., 1906, **132**, 889-891.

III. **Indexes of Body Resistance.** Several of these have been orginated by various workers in this field. That of Walker's[2] we think is the best. It is computed in the following manner: He takes 10,000 as the highest possible normal total leukocyte count and 70 as the greatest possible normal polymorphonuclear percentage. For each rise of 1 per cent of the polymorphonuclears above 70 there should be an increase in the total count of 1000 above 10,000. Thus if the polymorphonuclear percentage is 80 (10 above 70) the total count should be 20,000 (10,000 above 10,000), in order to make the index normal, or zero. If in this instance the total should rise to 25,000, the index would be +5; if to 30,000, +10, etc. On the other hand, still assuming the polymorphonuclears to be 80 per cent, if the total leukocytes were only 15,000 they would be 5000 lower than they should be, making an index of −5; if they were only 10,000 the index would be −10, etc. In the cases of pneumonia, influenza, measles and empyema, which Walker cites, the index nearly always is positive if the disease is progressing favorably; negative, if it is serious; and invariably negative in all fatal cases.

IV. **Miscellaneous Data.** Ether anesthesia, operative trauma, moderate shock, moderate hemorrhage, physical exercise, reclining posture, short cold baths, pregnancy, normal digestion, diurnal factors, geographic location, elevation and personal idiosyncrasies usually cause more or less increase in the total white count.

Personal Investigations. This description of our work is in the nature of a report preliminary to further efforts along these lines. Although our conclusions are, we think, in the main correct, yet they are to some extent tentative, because knowledge in this field of hematology is by no means complete at present.

Our counts were made by means of a Levy counting chamber with Neubauer rulings. Two hundred or three hundred cells were enumerated each time. The blood samples were taken at various times of the day; it usually was impracticable to get them the same hour each day when two or more counts were made on the same individual. From one to fifteen counts were made on each patient, at intervals varying from six hours to twenty-four days.

Wright's stain was used, although we were fully aware of the fact that some specialists in this field do not hold it in high esteem. As far as we are concerned, we feel very grateful to Wright for devising his stain, for without rapidity of method thus made possible we would have been unable to obtain sufficient time from our busy routine to make the examinations which form the basis of this article. While Wright's stain does not bring out all cytologic details that every hematologic investigation requires, yet it was

[2] An Index of Body Resistance in Acute Inflammatory Processes, Jour. Am. Med. Assn., 1919, **82**, 1453–1457.

ample for our purpose, for we needed a stain which would enable us merely to distinguish polymorphonuclears from lymphocytes and also differentiate these two groups from the various other commoner varieties. Wright's stain when rightly handled accomplishes these results satisfactorily.

Our counts were made on patients suffering from the following diseases: 21 cases of appendicitis ranging in severity from very mild to fatally severe; 2 cases of puerperal infection; 2 secondary infections of laparotomy wounds; 1 each of the following: abscess of the kidney; abscess of retroperitoneal sarcoma; pelvic abscess following radium treatment; abscess of the lung following traumatic infection of the arm; abscess of tooth; acute pelvic gynecologic infection (?); eclampsia; postpneumonic empyema; cyst of spleen; acute lobar pneumonia; infection and gangrene of ovarian cyst complicating pregnancy; chronic salpingitis and retroflexion of uterus; recurrent pyelitis with salpingitis (?); chronic cholecystitis; nephroptosis; incomplete intestinal obstruction; mucous colitis; pyelonephritis; mild cerebral hemorrhage; posttyphoid lumbago; uterine hemorrhage, chronic cervicitis, and retrodisplacement of uterus; myocarditis, endocarditis, and appendicitis (?); one undiagnosed case. All of above patients except 4 were occupants of South Highlands Infirmary.

We will discuss our cases in regard to the hematologic principles we wish to elucidate rather than according to the various kinds of inflammatory diseases we have investigated, for in the class of infections considered in this report we found these principles to be practically the same, regardless of the nature of the invading bacteria or the portion of the body attacked.

General Explanation of Figures. The total leukocyte count was obtained according to the usual method. The percentage of polymorphonuclears was ascertained by the ordinary procedure of counting spreads on slides. The total polymorphonuclears per cubic millimeter was computed by multiplying the total count by the percentage of polymorphonuclears. Walker's index was worked out according to the method already described (p. 554). The total number of lymphocytes per cubic millimeter was obtained by multiplying the total leukocytes by the percentage of lymphocytes (taken from the differential count).

The line in the upper portion of each figure extending to the right on a level with "10,000" indicates the highest possible normal number of total leukocytes. The first line below this designates 7000 as the highest possible normal total number of polymorphonuclears. The line on a level with "70" signifies the highest normal percentage of polymorphonuclears. The line to the right from "zero" denotes normal resistance according to Walker's index. The lowest line on the right side indicates 1000 as the lowest possible normal number of lymphocytes per cubic millimeter.

The vertical columns of arabic numerals are arranged so that exactly the same amount of vertical space is allowed for a change of 1000 in the total leukocytes or total polymorphonuclears, for a variation of 1 per cent in the percentage of polymorphonuclears, and for a shifting of one point in Walker's index. The vertical intervals under "Total Lymphocytes" have no definite relations like those just described.

1. **Total Leukocyte Count.** Many if not the majority of clinicians look upon a rise of the total leukocyte count above normal in most acute inflammatory diseases as one of the indications of the presence of infection, and consider that a fall back toward normal means an improvement in the patient's condition; also, that the severity of the process corresponds fairly closely with the degree of the leukocytosis and the range of its fluctuations. The first point to stress in this connection is that the total count often is of little value in estimating the state of the patient. In fact, it may be positively misleading. For example, in Fig. 4, the fall of the total count from November 11 to 19 marks an exacerbation of the patient's infection. In Fig. 2 note that throughout the illness there was relatively little change in the total count and that it fell only from 16,000 to 11,000, a drop not corresponding clinically to the patient's prompt recovery from the operation. In Fig. 6 notice the decline of the total count from June 12 to 17, which parallels a marked aggravation of the patient's condition; the decided rise June 20 to 21 coincides with a very marked clinical improvement. Fig. 5, a fatal case, shows a gradual descent of the total count during the sixteen days immediately preceding the patient's death. This independent behavior of the leukocytic count occurs so frequently that by following along the rises and falls of the leukocytes from count to count one can find in every figure of this paper from one to five instances in which the total number of leukocytes either (1) rises with an improvement in the patient's condition or (2) falls with an exacerbation of the infection or (3) remains practically stationary while the clinical course either improves or gets worse—all three of these combinations being contrary to the significance commonly assigned by clinicians to the total leukocyte count.

On the other hand in many if not most instances the *general trend* of the total leukocytes does go hand-in-hand with the clinical course. Refer to Fig. 1, where the general direction of the leukocytic curve is downward while the patient at the same time makes a good recovery. This parallelism does not hold true, however, if one considers details too closely, for the drops from September 29 to August 1 and from August 3 to 4 were accompanied by aggravations of the patient's infection. But the general direction of the line does point toward the excellent recovery which the patient made. Figs. 2, 3, 4 and 6 illustrate cases precisely similar to the

one just described. Note also in a fatal case, Fig. 5, that the general course is downward, but not as markedly so as in the cases which recovered.

The most outstanding fact to be observed concerning the clinical significance of the total number of leukocytes is that they constitute the chief hematologic manifestation of the amount of resistance the body is making against the invading organisms. It is always a bad sign for the total leukocytes to register low unless the percentage of polymorphonuclears is correspondingly small. If the latter are high and the total leukocytes are low this combination means that a poor resistance is being offered against a severe inflammation—a situation which must be corrected if the patient is to recover. (See Fig. 5, September 24; this patient died. Compare Fig. 2, June 27, and Fig. 6, June 18 and 20.)

2. **Total Polymorphonuclear Count.** This parallels closely the total leukocytes. In comparing the two lines it is seen that they almost invariably lie relatively close together when the patient's condition is more or less serious, and separate from each other with clinical improvement. In Fig. 1, September 29, the patient's resistance is good and the two lines lie well apart; by October 1, the resistance had decreased markedly and the lines are twice as close together. On October 3 there was a decided improvement in the resistance and the lines at once separate from each other. In Fig. 6 note how close these lines lie to each other June 18 when the patient is at her worst, and how they gradually diverge as she recovers. All of the figures accompanying this article illustrate this principle very well. The approach and the spread of these two lines in relation to each other is an entirely new discovery of the senior author, and taken alone, independent of other hematologic findings, it constitutes an excellant guide to the patient's true clinical state.

3. **Percentage of Polymorphonuclears.** Of all the elements of a leukocyte count this probably is the most valuable. If these run high they mean a severe inflammation which usually, but not always, is purulent or gangrenous or both; and if the patient is to recover, relief must be obtained either spontaneously or by artificial means.

We would like to emphasize at this point the futility of trying to foretell with certainty whether pus is present by the degree of polynucleosis. (See Tables 1 and 2, which show that pus was found in the lesions with percentages of polymorphonuclears ranging from 64 to 94, and that pus was absent with percentages of 64 to 93.) But whether there be pus and gangrene or not a high polymorphonulcear count means practically without fail a severe inflammation or a marked toxemia of some kind. The nature of the invading bacteria very likely plays a part in this respect. Thus we know that certain streptococci may produce a

severe inflammation and marked toxemia with but little or no purulent exudate. On the other hand, bacteria of low virulence, like many strains of colon bacilli, may produce large abscesses with so little toxemia that there is no reaction on the part of the blood. Again, the infection may be virulent but the patient fails to put up a fight; in this case the blood is negative. Finally, the infected area may be so thoroughly walled off that there is no absorption of toxins and hence no hematologic response.

From a practical standpoint, however, the problem of diagnosis usually is solved sufficiently to determine an effective mode of procedure by correlating the blood findings with the clinical history and the physical examination. In this connection one must remember that high counts are of greater value than low ones in making a positive diagnosis, unless the latter follow the former. For example, in Fig. 4 a drop in the polymorphonuclears from 88 per cent to 68 per cent from November 29 to December 18 can mean but one thing, namely, a marked improvement in the pathologic process. The successive drops in Fig. 6, June 18 to 25, have exactly the same significance. The opposite sequence of a high following a low percentage has precisely the opposite meaning and can be relied upon implicity. (Refer to Fig. 5, September 21 and 24, and Fig. 6, June 17 and 18.)

4. **Polymorphonuclear (Walker's) Index of Body Resistance.** The nature of this index and the method of its computation have already been explained. We have been able to verify practically every claim that Walker makes for it. Minor fluctuations, as one might expect, frequently seem to have no clinical significance. However, in practically every case of ours that terminated favorably the index ascended well above normal (zero) and many times very far above it. (See Figs. 1, 2, 4 and 6, where the rises at recovery were only a moderate distance above zero.) In these patients recuperation was satisfactory but not as prompt and complete as in the case illustrated in Fig. 3, where the index rose enormously above normal. The case shown in Fig. 5, which ended fatally, had a very low index, never attaining normal.

Caution should be exercised in interpreting Walker's index when on or near the zero line except in connection with the percentage of polymorphonuclears. While in patients that have practically recovered the index may be at or near normal, the same is also true frequently of those suffering severe inflammations. For example, in Fig. 4, December 18, the index is approximately at zero, the total and polymorphonuclear counts are within normal limits and the patient has overcome almost completely her very severe infection. Now compare Fig. 6, June 12, P.M., when also Walker's index is at zero but the polymorphonuclears are at 88 per cent. The following morning the index has dropped to six below normal, and laparotomy the same day revealed an infected

gangrenous ovarian cyst. Compare again two more cases: in Fig. 1, October 18, the index is near the zero line (slightly above), the total leukocytes and the percentage of polymorphonuclears are practically normal and the patient has almost completed a clinical recovery. Compare Fig. 3, January 17, where the index also is approximately the same but the patient's polynuclears are 82 per cent, and he is very ill, suffering from a severe toxemia. The importance of always evaluating a normal Walker's index in connection with the percentage of polymorphonuclears may be better appreciated by likening a normal index accompanied by a normal polymorphonuclear count to a good dam with normal water-pressure behind it. No questions are asked; no fears arise. On the other hand normal index with a high polymorphonuclear percentage is like the same dam with a high water-pressure back of it. The question is asked at once, will the dam hold the flood? And one may fear the consequences if the structures should break. Similarily, if a patient's index is normal and his polymorphonuclears are high, one seeks to estimate whether the patient will be able to maintain his resistance and what the consequences will be if he fails.

Of course what one dreads most of all are marked depressions in the index caused by a high polymorphonuclear percentage and a low total leukocyte. (See Fig. 1, October 2; Fig. 2, June 27; Fig. 3, January 20; Fig. 5, September 24 and 27; and Fig. 6, June 18 and 20.) If a patient does not recover with reasonable promptness from such low readings as these he is almost sure to suffer dire consequences.

5. **Total Number of Lymphocytes per Cubic Millimeter.** These were computed by multiplying the total leukocyte count by the percentage of lymphocytes. Three features are particularly outstanding in regard to the total lymphocyte count:

Taken by itself it constitutes a very reliable index to the patient's condition. The lymphocytes almost invariably increase with the patient's improvement and decrease when the infection is worse; and they always rise high when recovery has become complete. Every figure in this article illustrates this point. In fatal cases the total lymphocytes remain close to or below lowest normal (1000). (See Fig. 5.)

The second point of interest is the discovery the senior author has made that the total lymphocyte curve parallels almost exactly the polymorphonuclear (Walker's) index of resistance. Every figure shows this feature. Why in rare instances (*e. g.*, Fig. 3, February 1 to 5) they run in opposite direction we are as yet unable to explain.

Concerning the relation of the total lymphocytes to the total leukocytes and to the percentage of polymorphonuclears, practically the same can be said that was stated in connection with the

polymorphonuclear (Walker's) index. The points to be noted are as follows: (*a*) A low lymphocyte count with a low or only moderately high percentage of polymorphonuclears is not a bad sign; and if at the same time the total leukocytes are high the outlook is favorable. (See Fig. 1, October 3 and 4.) This combination of low lymphocytes and low percentage of polymorphonuclears does not occur often, because when the percentage of polynuclears goes down the number of lymphocytes per cubic millimeter usually (but not always) increases reciprocally. (*b*) A low total lymphocyte enumeration with a high percentage of polymorphonuclears and a high total leukocyte count indicates a more or less serious condition. This is the most frequent combination found. (Refer to Fig. 4, November 11; and Fig. 6, June 12.) (*c*) A low total lymphocyte count with a low or only moderately high total leukocyte count and a high percentage of polymorphonuclears constitute a combination which signifies a very serious state that frequently ends fatally. This situation is encountered in a rather small percentage of patients. (See Fig. 4, November 19 to 29, and Fig. 5, September 24) [a fatal case].

6. **Correlation with Clinical Findings.** An extensive blood picture as described above has its final significance only when evaluated in connection with the clinical history and the physical examination. Two features in this connection deserve special emphasis: (*a*) The fact whether the organ involved is vital and (*b*) the possibility of relief from the inflammation either spontaneously or by surgical or by other procedures. For example, in Fig. 4, we have a blood picture which betokens a serious state when studied alone; but when one considers also the clinical facts that the abscesses did not invade vital organs and also that they could be and were efficiently treated (by drainage) we find a large part at least of the explanation of the patient's complete and fairly prompt recovery. (Study Fig. 5, too.) Here every feature of the blood picture is bad. The total leukocytes are low, indicating a poor resistance; the percentage of polymorphonuclears is high, demonstrating a severe infection; the index is very low and the total lymphocytes are down. The organ involved, a lung, is a vital one; and efficient treatment (by drainage or otherwise) was very difficult. If the part of the body invaded had been the appendix the patient probably would have recovered, other things being equal; for the appendix not being a vital organ (and being readily accessible) can be removed, and an appendicular abscess can be effectually drained. In Fig. 6, June 18, the blood picture looks very bad *per se;* but when one discovers that it is due to an abscess in the abdominal wall the picture takes on a lighter hue; for the wall of the abdomen is relatively not a vital portion of the body, and it is easy to treat curatively most abscesses which occur in this anatomic location.

7. **The Extent and the Form of the Leukocytic Blood Picture.** When making a blood examination we wish to emphasize the importance in all serious cases of including most if not all of the features described above. Without the total leukocyte count one is in the dark as to the amount of resistance the patient is offering. Without the percentage of polymorphonuclears one does not know the severity of the inflammation. Without Walker's index one is deprived of a lucid means of expressing the relationship between the total leukocytes and the percentage of polynuclears. Without the total lymphocyte estimation one misses valuable confirmatory evidence. A knowledge of the total number of polymorphonuclears per cubic millimeter is a distinct aid but is of the least value of any of the five features constituting our blood picture. The most important of all, without doubt, is the percentage of polymorphonuclears.

An examination of this sort may seem long and complicated to one who has not done several of them; but all that is involved beyond an everyday total and differential count is a few brief calculations and the printing of the blank charts. In our laboratory at present we are making the charts by hand; but later, when we feel we have digested the subject more thoroughly, we will have the printer stock us with a supply.

We wish to direct attention especially to the manner in which the data are charted. It is utterly impossible to convey adequate information to the mind through the eye by means of written characters collated in ordinary tables. We made tables for all of our cases, and of course obtained valuable knowledge from them; but the added information acquired when we transformed these plain tables into graphic charts was like a flood of light thrown into a poorly illuminated room. Charts with horizontal lines, one for each element of the picture (or constructed according to this principal) are very essential. This method gives perspective and throws into the foreground certain important features which otherwise remain unnoticed.

The Value of a Small Number of Leukocytic Counts. Very many writers emphasize the importance of making a considerable series of counts on any given patient in order to acquire information of appreciable use, and they deprecate the value of one count alone. We wish to emphasize the value of single counts. For example, in Case 6, Table 1, the surgeon relied completely on the blood picture from one examination to determine immediate operation. In nearly every case charted in this table the high percentage of polymorphonuclears, the negative Walker's index, the relatively small number of lymphocytes and the relatively large total count obtained from single examinations constituted exceedingly valuable evidence, and the story which these findings told was almost invariably confirmed clinically. On the other hand, low percent-

ages of polymorphonuclears and positive indices of resistance helped greatly to confirm the clinical diagnosis of mild and non-purulent lesions. Nearly all of these blood features were confirmed by operation or otherwise.

Conclusions. 1. That the details of the total white count considered alone have but little value as a prognostic index is evinced by the fact that segments of the curve may rise or fall or remain stationary while the patient's true condition is becoming either better or worse or is unchanged. However, the *general trend* of a curve composed of several counts, disregarding minor ups and downs, usually does have significance: a general downward course, other things being equal, parallels clinical improvement; an upward direction is of ill omen, and a horizontal course indicates but little change. We wish to emphasize most of all the fact that the total leukocyte count is a measure of the amount of resistance the patient is offering against the inflammatory process.

2. The count of the total polymorphonuclears runs somewhat parallel with that of the total leukocytes. However, this parallelism is not complete. We have made the discovery that these lines approach closest to each other when the patient's condition is the worst, and are farthest apart when he has returned to normal. Thus the convergence and the divergence of these two lines constitute a very good prognostic index to the course of an inflammatory disease.

3. The percentage of polymorphonuclears constitute a very reliable indication of the severity of an inflammation. A high percentage means a severe process almost without fail, and a low figure means a mild infection; but probably the low count cannot be relied upon to demonstrate absence of infection and especially of pus to the extent that a high count can be trusted to indicate a severe infection—usually with pus or gangrene or both.

4. The polymorphonuclear (Walker's) index of resistance is an exceedingly reliable prognostic guide. However, readings near normal (zero) must be interpreted in connection with the other features of the blood picture, especially the percentage of polymorphonuclears. If these are high the condition is serious or at least may become so, while if the polymorphonuclears are within the normal limit there is but little cause for apprehension. A very low index means by itself a serious condition, for the index cannot drop far unless the percentage of polymorphonuclears (measuring the severity of the inflammation) rises high or relatively high and unless at the same time the total leukocytes (indicating body resistance) register low or relatively so.

5. The total number of lymphocytes per cubic millimeter constitutes a very reliable index of a patient's state of resistance. A reading near or especially below lowest normal (1000) is unfavorable. The auspicious cases remain well above this danger

line. We have made the original discovery that the curve of the total lymphocytes parallels Walker's index (in the class of cases investigated), and also it seems to have practically the same significance as Walker's index; but like the latter it must be interpreted in connection with the percentage of polymorphonuclears and the total leukocyte count.

6. A hematologic picture has its true significance only when interpreted in connection with the clinical findings. While many of these are important, we wish to emphasize two: (1) the fact whether the part of the body concerned is vital, and (2) the possibility of relief, either spontaneously or by surgical or other means.

7. We consider that none of the features of the hematologic picture we have presented should be omitted in examining serious cases. However, if one must choose, there is no reasonable doubt that the total number of polymorphonuclears per cubic millimeter is the least important element and that the *percentage* of these same cells is the most important.

8. We desire to emphasize the value of a single blood examination, although, of course, we always prefer to get two or more counts, if possible, on any given case.

9. Negative findings have much value but are not to be relied upon as implicitly as positive ones.

10. We wish to emphasize the importance of depicting blood pictures in the form of graphic charts as described in this article, and we maintain that tables with written characters only, which omit the all expressive systems of lines, are very inadequate.

We regret that space will not permit the publication of our bibliography of about two hundred references.

TABLE I. This is made up to show the *value* of *single counts* in cases in which more than one enumeration was made. From two to twelve counts were made on each of these patients. One count from each case, in nearly every instance the one immediately preceding operation, was selected for this table. In Case 8 there was no visible discharge except the menstrual flow. The exact nature of the lesion never was ascertained because the patient did not come to operation. The count in Case 1 was immediately postoperative, which almost always is higher than a preoperative one. In case 47 the count was taken four days after operation—after the patient had improved greatly.

This table illustrates, among other features, the futility of attempting to diagnose with certainty the presence of pus by the percentage of polymorphonuclears or by the total count. Pus was present in percentages ranging from 64 to 94, and in total counts from 7,200 to 28,300. Pus was absent in percentages varying from 64 to 93, and in totals from 8,000 to 28,400. These findings are explained by the fact that there may be but little pus in a virulent infection and much pus in a mild one.

TABLE I.

Case.	Per cent polymorphonuclears.		Total leukocytes.		Diagnosis, etc.
	Pus or gangrene.	No pus.	Pus or gangrene.	No pus.	
38	77	..	6,500	.....	Abscess of kidney.
14	81	..	14,200	.....	Infection, puerperal; no operation.
21	..	75	.....	11,500	Appendicitis, acute; burn of foot.
8	..	93 (?)	.....	23,500	Infection, acute pelvic; acute gastritis; no operation.
4	81	..	16,000	.....	Abscess of retroperitoneal sarcoma.
1	..	84	.....	28,400	Eclampsia; Cesarean section.
3	..	66	.....	8,900	Appendicitis, acute catarrhal.
2	85	..	28,300	.....	Appendicitis, acute, purulent, gangrenous.
16	86	..	15,400	.....	Appendicitis, acute, purulent, gangrenous.
46	82	..	22,000	.....	Appendicitis, acute purulent.
47	69	..	12,000	.....	Empyema, postpneumonic. Patient two years old.
32	70	..	7,200	.....	Thrombophlebitis, puerperal, pelvic.
13	..	93	.....	28,200	Cyst of spleen; no gross signs of infection.
13	84	..	15,000	.....	Infection, secondary, of laparotomy wound.
7	90	..	25,000	.....	Pneumonia, acute lobar; no operation.
31	91	..	13,000	.....	Abscess, pelvic; following radium treatment uterus; three operations.
11	89	..	10,000	.....	Abscess of lung; following traumatic infection of arm.
24	91	..	17,200	.....	Appendicitis, acute, purulent, gangrenous.
5	64	..	7,400	.....	Appendicitis, acute purulent.
17	..	64	.....	8,000	Appendicitis, subacute.
48	87	..	27,000	.....	Infection and gangrene, acute, of ovarian cyst (twisted pedicle).
48	94	..	16,000	.....	Infection, secondary, laparotomy wound.

BURN OF FOOT—ACUTE NON-PURULENT APPENDICITIS

FIG. 1.—Case 21. Burn on the foot; acute appendicitis. Patient of Dr. S. L. Ledbetter, Jr. Mr. W. O. M. Age twenty-eight years. In hospital, September 25 to October 18, 1920. Patient entered hospital with a burn on the foot. After several days pain in chest developed accompanied by nausea and vomiting. There was no particular tenderness in the abdomen at first. Later, there appeared distinct localizing symptoms in the region of the appendix.

Operation and Pathology. Laparotomy by Dr. Ledbetter, October 5, 1920. No drainage. Appendix was large, red and swollen, but there was no macroscopic pus.

Postoperative Course. This was practically uneventful. Patient felt bad October 1; better on October 2; better on the 3d; about the same, on the 4th; not so well on the 5th. Temperature and pulse remained practically normal throughout convalescence. He was up in a chair October 13, and went home on the 18th.

TABLE II.

Case.	Total leukocytes.		Per cent polys.		Walker's index.		Total lymphocytes.		Diagnosis, etc.
	Pus or gangrene.	No pus.	Pus or gangrene.	No pus.	Pus or gangrene.	No pus.	Pus or gangrene.	No pus.	
6	18,800	.....	95.5	....	−16.7	.....	660	....	Appendicitis, acute; no macroscopic pus; gangrenous mucosa.
9	.....	12,200	....	64	.....	+8.2	....	3,900	Appendicitis, chronic; ulcer, gastric.
10	.....	8,200	....	71	.....	−2.8	....	1,930	Appendicitis, chronic.
12	.....	9,100	....	66	.....	+3.1	....	2,730	Salpingitis, chronic; retroflexion of uterus.
15	.....	6,000	....	65	.....	+1.0	....	1,260	Pyelitis, recurrent; salpingitis (?); no operation.
18	11,600	.....	84.0	....	−12.4	.....	1,220	....	Appendicitis, acute; pus abundant.
19	8,000	.....	56.5	....	+11.5	.....	3,120	....	Appendicitis, acute; amount of pus very small.
20	.....	6,800	....	59	.....	+7.8	....	2,210	Appendicitis, chronic; cystic ovary.
22	.....	9,500	....	57	.....	+12.5	....	3,090	Appendicitis, chronic.
23	14,300	.....	92.5	....	−18.2	.....	715	....	Cholecystitis, subacute; pus (?)
25	24,900	.....	83.5	....	+1.4	.....	3,490	....	Appendicitis, acute; gangrene; abundant pus.
27	.....	13,600	....	85	.....	−11.4	....	1,630	Nephroptosis; no operation; pus (?)
28	15,300	.....	87.5	....	−12.2	....	1,610	....	Appendicitis, acute; large amount of pus.
29	30,100	.....	95.0	....	−4.9	.....	1,050	....	Appendicitis, acute; gangrene; much pus.
30	27,300	.....	92.5	....	−5.2	.....	1,230	....	Appendicitis, acute; gangrene; much pus.
33	.....	8,300	....	56	.....	+12.3	....	3,200	Undiagnosed; no symptoms of acute infection; no operation.
34	.....	6,000	....	70	.....	+4.0	....	1,560	Obstruction of intestine, incomplete; no operation.
35	10,400	.....	65.0	....	+5.4	.....	3,220	....	Abscess of teeth, chronic; very little pus; teeth extracted.
36	.....	6,200	....	57	.....	+9.2	....	2,390	Appendicitis, chronic.
37	24,400	.....	85.0	....	−0.6	.....	2,810	....	Appendicitis, acute; gangrene; much pus.
39	.....	10,200	....	70	.....	+0.2	....	2,350	Colitis, mucous; no operation.
40	.....	6,200	....	65	.....	+1.2	....	1,740	Pyelonephritis; symptoms not acute; no operation.
41	.....	10,300	....	60	.....	+10.3	....	3,910	Hemorrhage, mild cerebral; no operation.
43	.....	15,200	....	74	.....	+1.2	....	2,900	Myocarditis and endocarditis, subacute; appendicitis (?); no operation.
44	.....	8,000	....	65	.....	+3.0	....	2,560	Lumbago, posttyphoid; no operation.
45	.....	10,400	....	63	.....	+7.4	....	3,330	Hemorrhage, uterine; cervicitis, chronic; retrodisplacement of uterus.
Averages	18,500	9,100	83.7	65.4	−5.2	+5.1	1,910	2,540	
Ranges	8,000 to 30,000	6,200 to 15,200	56.5 to 95.5	57 to 85	−18.2 to −11.5	−11.4 to −12.5	660 to 3,490	1,260 to 3,910	

TABLE II.—This is made up from patients on whom *single counts only* were taken. All were operated upon unless otherwise stated. Under total leukocytes note that while the average count is much higher in the purulent than in the non-purulent cases, yet it is possible to have pus with rather low counts, for example, 8,000 and 10,000 (Cases 19 and 35). In these instances, however, the amount of pus was so small as to be almost negligible. When any considerable amount develops the counts run from 12,000

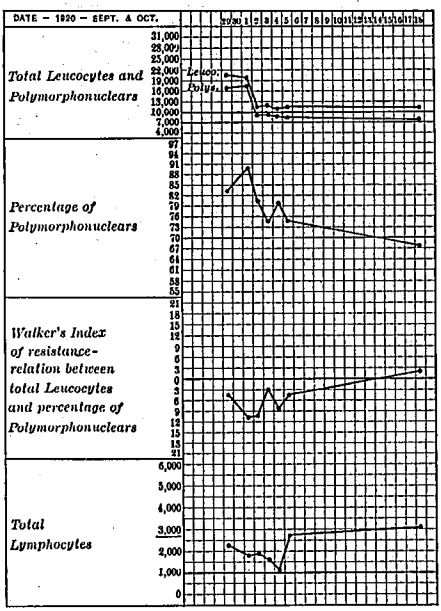

FIG. 1.—See general explanation, p. 555, and description in text.

to 30,000. And still with a high count there may be little or no pus (Case 6). In the non-purulent cases none of the counts are high, the largest being 15,200 (Case 43). Note that the range is 100 per cent greater with the purulent lesions.

In regard to the percentage of polymorphonuclears a low figure does not exclude pus, but the amount is apt to be small, for example, 56.5 per cent and 65 per cent in Cases 19 and 35. Percentages ranging from just above 80 to 95 show marked virulence and at the same time considerable pus usually, but not always; for,

observe that Case 6 with a percentage of 95.5 exhibited no macroscopic pus. The range of variation is greater by 30 per cent in the purulent than in the non-purulent cases.

Walker's index is usually minus in the pus cases and plus in the clean or relatively clean ones. Notice that the pus column has only three plus indices, two of which scarcely belong here because of the very small amount of purulent exudate. In the no-pus series there are only two minus indices. The purulent cases average minus 5.2 and the non-purulent ones plus 5.1.

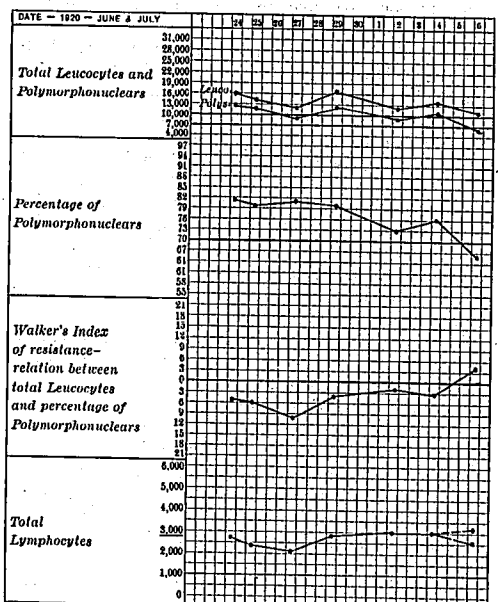

FIG. 2.—The count July 6 showed an erratic rise of the endothelial leukocytes to 8 per cent; this increase occurred at the expense of the lymphocytes. By counting the excess of endothelials in with the lymphocytes a slight increase in the total lymphocytes is produced as indicated by the dotted line. For further elucidation, see general explanation, p. 555, and description in text.

The total lymphocytes average lower by about 30 per cent in the purulent than in the non-purulent conditions. Also the range is somewhat greater in the former than in the latter. And still more significant are the low levels, well below 1000, to which the purulent cases now and then drop (Cases 6 and 23). This almost never occurs with the non-purulent lesions.

FIG. 2.—Case 4. Abscess of retroperitoneal sarcoma. Patient of Drs. E. M. Prince and D. S. Moore. Mrs. S. J. A. Aged forty-five years. In hospital June 24 to July 8, 1920. She had been in the hospital for a few days prior to the middle of June, 1920, with a history of gall-stone colic, and a diagnosis of cholelithiasis was made at that time. No other symptoms were present, and she was discharged without operation.

She returned June 24, 1920, suffering with acute pain, which had begun five days previously and which extended over her entire abdomen. Preoperative diagnosis of appendicular abscess was made.

Operation and Pathology. Laparotomy by Dr. E. M. Prince, June 24, 1920. Drainage. A large retroperitoneal sarcoma was found, in the interior of which was a large abscess. One large gall-stone was found in the gall-bladder.

Postoperative Course. On the whole she made a rather uneventful recovery. Temperature, June 24 to 28 was 97° to 102°; 29 to 30, 98° to 100.4°; July 1 to 3, 99° to 101°; 4 to 8, 98° to 100°. There were marked rises and falls the same day during the early part of her illness. Patient's pulse followed her temperature, ranging from 80 to 120. It was weak a few hours after operation, when hypodermoclysis was given. Respirations varied from 20 to 30. She suffered much from gas pains, etc. Many enemas were given and she was catherized several times. Her condition was the least favorable on June 27. The wound drained freely and her condition improved until she sat up with a back-rest July 7, and was taken home the following day in good condition.

FIG. 3.—Case 46. Acute purulent appendicitis. Patient of Drs. E. M. Prince and D. S. Moore. Mr. R. S. Aged twenty-seven years. In hospital January 17 to February 6, 1920. His symptoms were pain in the epigastrium, nausea and vomiting; moderate temperature; tenderness and rigidity in the region of the appendix. Trouble began the forenoon of the day the patient entered the hospital, and he was operated the same day about 8.00 P.M.

Operation and Pathology. Laparotomy by Dr. Prince, January 17, 1921. Drainage. Appendix was ruptured and there was a moderate amount of pus. No adhesions had formed.

Postoperative Course. Recovery was very satisfactory. Wound drained freely and there was still a little discharge when the patient left the hospital. Temperature at the time of operation was 102.68; this had fallen to normal by the nineteenth, and there was no subsequent rise. Pulse corresponded to temperature. He was on a back-rest the third and walked the sixth.

FIG. 4.—Case 31. Pelvic abscess; secondary in right iliac region; tertiary in left iliocostal space. Patient of Drs. E. M. Prince and D. S. Moore. Mrs. W. H. Aged forty years. In

hospital November 10, 1920, to January 16, 1921. Patient had received two treatments of radium for uterine hemorrhage, the last exposure being made a few days prior to her entrance to the hospital. After her first treatment her bleeding was lessened and after the second it stopped altogether; but a dark, malodorous vaginal discharge of moderate quantity appeared. During the twenty-four hours before she came into the hospital she had three chills and her temperature rose as high as 104°. She was observed for ten days in the hospital, when finally induration in addition to tenderness developed in the hypogastrium.

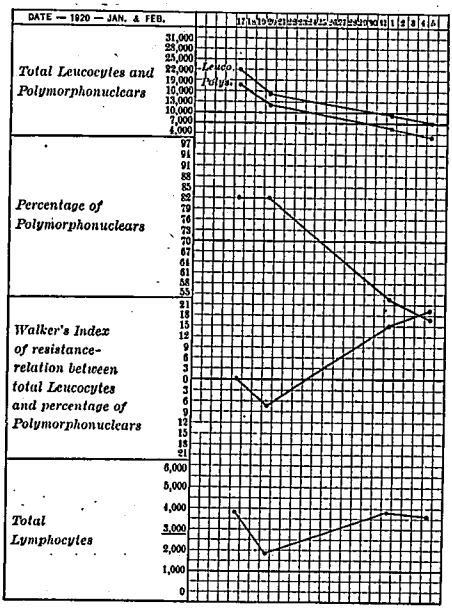

FIG. 3.—See general explanation, p. 555, and description in text.

Operations and Pathology. Laparotomy by Dr. D. S. Moore, November 20, 1920. Median incision above symphysis pubis. Drainage. A large amount of yellow, foul-smelling pus was evacuated; its origin was not ascertained.

November 27. Drainage incision in right inguinal region by Dr. Moore. A considerable, thick, rather malodorous pus was obtained; its source was not ascertained.

December 5. Drainage incision in left iliocostal space by Dr. E. M. Prince. A large amount of thick greenish-yellow pus escaped; its ultimate source was not discovered.

Postoperative Course. After the first operation the temperature ranged mostly from 100° to 103°; pulse, 85 to 105; respirations, about 20. After the second operation there was but little apparent change. Following the third incision the temperature, pulse,

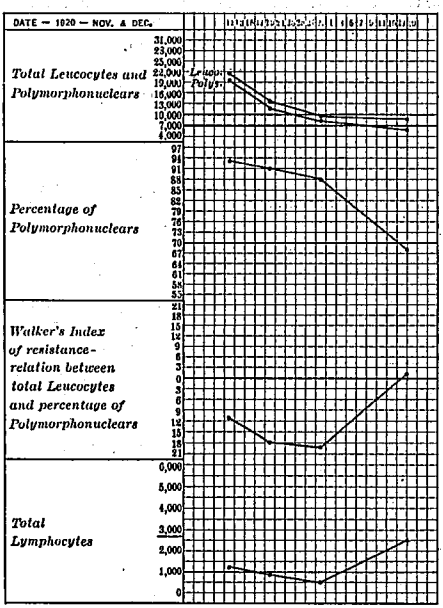

FIG. 4.—See general explanation, p. 555, and description in text.

etc., gradually returned to normal, reaching it for the first time permanently about December 30, although by December 18, there was marked improvement. All drainage had ceased by January 14, 1921, and January 16 the patient was discharged cured.

TRAUMATIC INFECTION IN RIGHT ARM; METASTATIC ABSCESSES IN LUNGS.

FIG. 5.—Case 11. Traumatic infection in right arm; metastatic abscesses in lungs. Patient of Drs. E. M. Prince, D. S. Moore

and C. Lull. Mr. W. J. J. Aged thirty-two years. In hospital September 10 to 28, 1920. Discharged from army on account of beginning locomotor ataxia. About six weeks prior to entering hospital he acquired a traumatic infection of the soft parts of the right arm near the elbow. About the time he entered the hospital signs of a metastatic abscess in the upper lobe of the right lung began to be evident. On September 22, roentgen-ray plates confirmed this diagnosis and showed also an abscess in the left lower lobe.

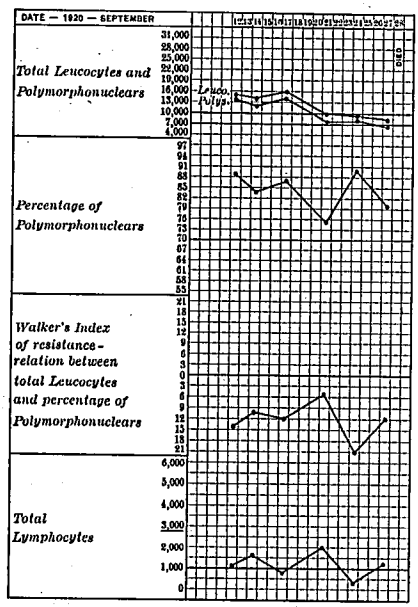

FIG. 5.—See general explanation, p. 555, and description in text.

Operation and Pathology. Incision and drainage of abscess in right lung by Dr. D. S. Moore, November 23, 1920. A large amount of pus was found.

Postoperative Course. Temperature rose and fell almost daily from about 99° to 104° throughout his illness while in the hospital. Pulse varied with the temperature, ranging from 110 to 140. Respirations were mostly from 20 to 25. There was no improvement after the drainage operation, November 23. He was expected to die November 24, but did not expire until November 28.

FIG. 6.—Case 48. Pregnancy complicated by infected, gangrenous ovarian cyst. Patient of Dr. Edward O'Connell. Mrs. A. McD. Aged twenty-nine years. In St. Vincent's hospital June 12 to 27, 1920. Married nine months. Prior to marriage, menstruation was irregular. Has had no abortions. Patient is about five months pregnant.

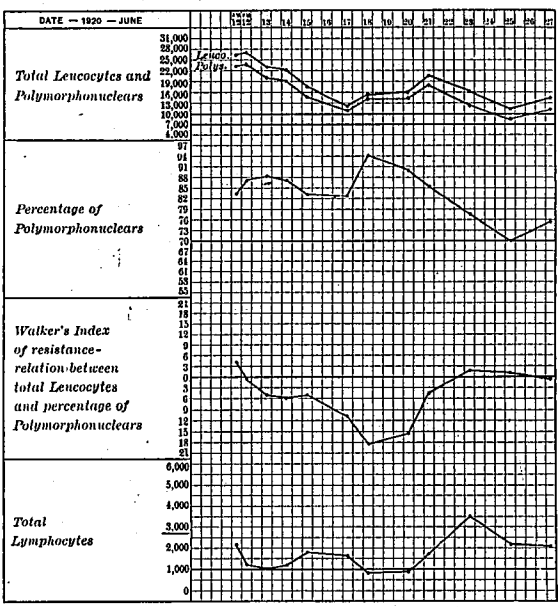

FIG. 6.—See general explanation, p. 555, and description in text.

About three months ago she began to complain of severe pain in the left side of the abdomen at intervals of about four days; this pain lasted four or five hours in each attack. Pulse and temperature were normal during intervals between attacks. She has been constipated and has suffered from headaches for about two months.

Operation and Pathology. Laparotomy by Dr. Watkins, January 13, 1921. Drainage. An ovarian cyst, about 18 cm. in diameter, was found, lying on the left side of the lower abdomen. The side of the cyst against the abdominal wall showed signs of moderate

inflammation. The pedicle was twisted and there was considerable beginning gangrene on the side toward the median line.

Postoperative Course. Temperature ranged from 96.2° to 100,° reaching the latter figure only once, namely, the day after operation. Pulse before operation was 108 to 110; the rest of the time it ranged from 78 to above 90, reaching 100 only January 19 and 20. Quality was practically normal all of the time. Respirations were 18 to 22, except during the two days before and three days after operation, when they ranged from 22 to 28.

There was some purulent discharge from the wound, especially January 18 to 20; on this latter day a large abscess was evacuated through the drainage opening. General condition of the patient was very good throughout the entire course of her trouble, and she went home January 27 in excellent condition. The pregnancy was not interrupted.

THE SURGERY OF THORACIC TUMORS.*

By Abraham O. Wilensky, M.D.
NEW YORK.

(From the Mount Sinai Hospital, New York.)

Intrathoracic surgery is still a pioneer field. We are fortunate in that much of the necessary groundwork has already been done in the physiologic aspects of the problems of intrathoracic surgery. The recent military emergency was a most valuable experience in that it gave to a large number of men a sense of security in operating within the thorax. So that many men have learned (1) the methods of incision which give maximum visibility within the thorax; (2) that the thoracic viscera may be manipulated without undue shock and without serious disturbance to the patient; (3) to control hemorrhage from the viscera; (4) that the lung may be cut and sutured and that parts of it may be removed safely; and (5) that intratracheal, intrapharyngeal or other forms of differential pressure anesthesia are not essential, although they are helpful and advisable when operating within the thorax. All of this experience is of the utmost value for the surgical problems of civil life.

More than anywhere else in the body the successful surgery of thoracic tumors has imperative need for early diagnosis. Then the lesion will be exposed when it is in its simplest and most uncomplicated state; when it is as small as possible, when its removal is not hampered by adhesions to vital structures or made impossible

* Read at a Symposium on Thoracic Tumors before the Yorkville Medical Society October 17, 1921.